IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:
Mackay, et al.

Serial No.: 10/616,061

Filed: July 9, 2003

Confirmation No.: Unknown

For: Expansion Method

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§ Group Art Unit: Unknown
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§ Examiner: Unknown
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37 CFR 1.8
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Dear Sir:

CLAIM TO PRIORITY

Applicant(s) reaffirm the claim for the benefit of filing date of the following foreign patent application referred to in Applicant's Declaration:

Great Britain Application Serial Number 0215918.4 filed July 10, 2002.

A copy of the application certified by the British Patent Office is enclosed.

Respectfully submitted,

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I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

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Dated 9 December 2002

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P01/7700 0.00-0215918.4

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The Patent Office

Cardiff Road
Newport
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NP10 8QQ

1. Your reference

AS\AM\P11600GB

2. Patent application number
(The Patent Office will fill in this part)

0215918.4

10 JUL 2002

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

WEATHERFORD/LAMB, INC.
515 POST OAK BOULEVARD
SUITE 600
HOUSTON
TX 77027
UNITED STATES OF AMERICA

Patents ADP number *(if you know it)*

If the applicant is a corporate body, give the country/state of its incorporation

DELAWARE CORPORATION

8028714001

4. Title of the invention

EXPANSION METHOD

5. Name of your agent *(if you have one)*

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

CRUIKSHANK & FAIRWEATHER
19 ROYAL EXCHANGE SQUARE
GLASGOW
G1 3AE
SCOTLAND
UNITED KINGDOM

Patents ADP number *(if you know it)*

547002

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*

a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
c) any named applicant is a corporate body.
See note (d))

YES

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	
Description	11
Claim(s)	8
Abstract	1
Drawing(s)	5

10. If you are also filing any of the following, state how many against each item.

Priority documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	1
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. I/We request the grant of a patent on the basis of this application.

Signature [signature] Date

CRUIKSHANK & FAIRWEATHER 9 JULY 2002

12. Name and daytime telephone number of person to contact in the United Kingdom

ANDREW SHANKS
0141 221 5767

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Notes

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EXPANSION METHOD

FIELD OF THE INVENTION

This invention relates to an expansion method, and in particular to a method of expanding tubing downhole.

BACKGROUND OF THE INVENTION

The oil and gas exploration and production industry is making increasing use of expandable tubing for use as casing and liner, in straddles, and as a support for expandable sand screens. Initially, expandable tubing was proposed for use primarily in combination with traditional fixed diameter casing and liner. However, more recently, various proposals have been put forward to utilise expandable tubing to create wells of substantially constant diameter ("monobore" wells), where all or at least a significant proportion of the well is lined with expanded tubing.

Various forms of expansion tools have been utilised to expand tubing downhole, including expansion cones and mandrels which are pushed or pulled through tubing by mechanical or hydraulic forces, and rotary expansion tools, which feature radially extending rollers which are urged outwardly into rolling contact with the tubing to be expanded while the tool is rotated and advanced through the

tubing.

It is among the objectives of embodiments of the present invention to provide sections of bore lined with expanded bore-lining tubing of a variety of diameters.

SUMMARY OF THE INVENTION

According to the present invention there is provided a method of expanding tubing downhole, the method comprising the steps of:

providing tubing of a first diameter;

running the tubing into a bore;

expanding a first section of the tubing to a second diameter; and

expanding a second section of the tubing to a third diameter.

The entire length of the tubing may be expanded, or a portion of the tubing may remain unexpanded, at said first diameter.

This aspect of the invention permits provision of expanded downhole tubing having sections of different diameters, to suit the individual requirements of respective sections of the bore. For example, a section of bore may have been underreamed, and it may be desired to line the bore with tubing which, when expanded, will define a larger diameter bore within the underreamed section and a smaller diameter bore beyond the ends of the reamed

section. In other applications, it may be convenient to have a section of lined bore defining a larger diameter to provide an annulus around, or otherwise accommodate, a relatively large diameter device or tool, such as a downhole pump. Thus it may then not be necessary to drill an extended section of bore of a large diameter where only a short section of a larger diameter is required and may be achieved by selective underreaming, provided of course that the large diameter tool or device may be run in through the smaller diameter bore section. In another application, it may be desired to expand a first section of tubing to a larger second diameter and into sealing contact with the surrounding bore wall, while it is desired to expand a second section of the tubing to a smaller third diameter to provide an annulus between the expanded tubing and the bore wall to accommodate a cement seal. The expansion of the first section in this method would preferably involve use of a compliant expander, that is an expander that has the ability to expand tubing to a non-uniform or non-circular form, and thus accommodate, for example, variations in the bore wall diameter.

The first and second expansion steps may take place simultaneously, and this may be achieved by providing first and second expansion tools on a common support, and operating the expansion tools simultaneously on different sections of the tubing. In this situation, the expansion

tools may take any appropriate form, including fixed diameter expansion cones. Of course, if an expansion cone is required to pass through a tubing section of smaller diameter than the expansion cone without expanding the section, the cone must be retractable or otherwise configurable to assume a smaller diameter, as described for example in applicant's US Patent No 6,012,523, the disclosure of which is incorporated herein by reference.

In other embodiments, the second expansion step may follow the first expansion step. In this situation, a common expansion tool may be utilised, such as a rolling expansion tool provided with radially extendable expanding members which may assume two or more diameters, the rolling members being arranged in a first configuration for the first expansion step and a second configuration for the second expansion step. Alternatively, different expansion tools may be utilised for the first and second expansion steps and may be mounted on different support members.

Where the third diameter is larger than the second diameter, the second section of tubing may be expanded to the second diameter before being expanded to the third diameter.

The tubing may be formed of a single tubing length, or may be formed of a plurality of tubing lengths which are joined end-to-end. The configuration of the tubing may be substantially constant, for example the tubing may consist

solely of solid walled tubing, or the configuration of the tubing may vary along its length, for example including solid walled sections and sections formed of expandable sand screen.

Where the tubing comprises a plurality of tubing lengths, these may be run into the bore and expanded separately. In one embodiment, the ends of adjacent tubing lengths may overlap. A first tubing length may be run into the bore and expanded to said second diameter. A second tubing length may then be run into the bore, beyond the first tubing length, but with the upper end of the second tubing overlapping the lower end of the first tubing. The upper end of the second tubing then be expanded to said third diameter, preferably such that the overlapping ends of the tubing are in sealing contact. The remainder of the second tubing may then be expanded to said second diameter. This process may be repeated for subsequent tubing lengths, to create a lined bore of substantially constant diameter, corresponding to the second diameter, but having relatively short sections of tubing where the diameter corresponds to said lesser third diameter. Typically, the difference between the second and third diameters will correspond to the wall thickness of the tubing and thus will be small, relative to the bore diameter. Nevertheless, the resulting profiles may be useful for locating tools and devices in the bore. The upper ends of the tubing sections may be

chamfered or otherwise profiled, to provide a smooth transition between the different diameter sections, or may provide a ledge or otherwise abrupt transition, to assist in locating tools or devices in the bores.

The invention also relates to bores lined in this manner.

In other aspects of the invention, tubing of a first diameter may be expanded, intermediate its ends, to a larger second diameter. That is, the tubing is expanded to create a "bulge" in the tubing.

In other aspects of the invention the tubing may initially feature sections of different diameters.

The invention also relates to apparatus for implementing the method, and to a bore lined in accordance with the method.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other aspects of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figures 1 and 2 illustrate steps in a tubing expansion operation in accordance with a preferred embodiment of the present invention;

Figure 3 illustrates expanded tubing following the expansion operation of Figures 1 and 2;

Figure 4 is a schematic illustration of a step in the

creation of a lined bore in accordance with a further embodiment of the invention; and

Figure 5 is schematic illustration of a section of a lined bore made in accordance with said further embodiment of the invention.

DETAILED DESCRIPTION OF THE DRAWINGS

Figures 1, 2 and 3 of the drawings illustrates a part of a drilled bore 10, of diameter D_1, which has been drilled to access a subsurface hydrocarbon-bearing earth formation 12. Where the bore 10 intersects the formation 12, the bore has been underreamed to a larger diameter D_2. A length of expandable tubing 14, of initial or first diameter d, has been run into the bore 10. As will be described, a first section of the tubing 14a is expanded to a second diameter d_1 within the section of the bore with a diameter of D_1, and a second section of the tubing 14b is expanded to a third diameter d_2 within the section of the bore with a diameter of D_2, as illustrated in Figure 3.

The expansion is achieved using a rolling expansion tool 20 which is run into the bore with the tubing 14, and is mounted on the lower end of a drill pipe string 22. The tool 20 comprises a hollow body 24 defining three radially spaced apertures 26 which each accommodate a respective piston 28 (only two shown), each piston providing mounting for a roller 30. The tool body 24 is in fluid

communication with the hollow string 22, such that hydraulic pressure may be applied to the tool body interior and thus urge the pistons 28 radially outwardly and bring the rollers 30 into contact with the tubing 14, as will be described below. The leading end of the body 24 provides mounting for further rollers 32 which are radially fixed in a conical configuration, the maximum diameter described by the rollers 32 being similar to the diameter described by the retracted or unextended rollers 30.

To expand the first section of tubing 14a, as illustrated in Figure 1, the tool 20 is rotated in the tubing and advanced axially through the tubing 14. The rotating rollers 32 subject the tubing wall to local compressive yield, leading to a decrease in wall thickness and corresponding increase in tubing diameter. The rollers 32 are configured such that the tubing tends to expand to the diameter d_1.

Once the first tubing section 14a has been expanded, pressurised fluid is supplied from surface to the expansion tool 20, which pressure urges the pistons 28 and the rollers 30 radially outwards as illustrated in Figure 2. By rotating and advancing the now energised tool 20, the tubing 14 is first expanded to the diameter d_1 by the action of the fixed diameter rollers 32 and then subsequently expanded, by a similar mechanism, to the diameter d_2, by the energised rollers 30.

Once the tubing 14 has been expanded as desired, the rollers 30 may be retracted, and the tool 20 retrieved through the expanded tubing.

Those of skill in the art will recognise that further operations will then be carried out, for example the expanded tubing may then be cemented and the second section 14b perforated.

Those of skill in the art will also recognise that this embodiment is merely exemplary of the present invention and that various modifications may be made thereto without departing from the scope of the invention. For example, the abovedescribed example features only two sections of tubing of two different diameters. In other examples, three or more sections of tubing of three or more different diameters might be provided. Furthermore, any appropriate form of expandable tubing and expansion tool or mechanism may be utilised, depending on the application.

Reference is now made to Figures 4 and 5 of the drawings, which illustrate the creation of a lined bore in accordance with a further embodiment of the invention.

Figure 4 illustrates an upper end of a drilled bore 40 within which a 9 5/8" conductor 42 has been located and cemented. In this example, the conductor 42 has a inner diameter (i.d.) of 8.5". A length of 29 lb/ft 7 5/8" (i.d. 6.8") casing 44 has then been run into the bore 40, such that the upper end of the casing 44 overlaps the lower end

of the conductor 42. The casing 44 has then been expanded, with the section of the casing 44 extending below the conductor 42 being expanded to provide an i.d. similar to that of the conductor 42, that is 8.5". However, at the overlap 46 between the casing 44 and the conductor 42, the casing 44 can only be expanded to an outer diameter corresponding to the inner diameter of the conductor 42; the conductor 42 has been cemented and thus cannot be expanded. Thus, at the overlap 46, the inner diameter of the throughbore defined by the conductor 42 and the expanded casing 44 is reduced by twice the thickness of the casing wall, that is twice 3/8", to 7.75".

The expanded casing 44 is cemented in the drilled bore, either prior to or following expansion. The expansion of the casing is achieved using a compliant roller expansion device, such as a fluid pressure actuated device as described above, which has the ability to expand the casing to the two different diameters, and be withdrawn through the smaller diameter overlap 46.

Figure 4 also illustrates a further section of casing 48 being run into the bore through the section of the bore already lined by the conductor 42 and the expanded casing 44. The casing 48 is identical to the unexpanded casing 44, and thus has an external diameter of 7 5/8" (7.625"), and thus may pass through the overlap 46, which has an internal diameter of 7.75".

The casing 48 is run into the bore 40 until the upper end of the casing 48 overlaps the lower end of the expanded, cemented casing 44. The casing 48 is then expanded and cemented, in a similar manner to the casing 44, and as illustrated in Figure 5, then provides a further section of lined bore with a major section of 8.5" i.d. and a short section of 7.75" i.d., at the overlap 50 between the casing sections 44, 48.

A bore may thus be drilled and lined as described above, with no loss of diameter as the bore is extended. The loss of diameter at the overlaps 46, 50 is relatively minor, and offers advantages in, for example, providing ledges or profiles useful in locating tools and other devices in the bore, and more than compensates for the technical difficulties involved in expanding the conductor 42 or outer casing 46 at the overlaps 46, 50; proposals to this end include cementing the tubing before cementing, or before the cement has set, or providing arrangements to retain the lower end of the conductor 42 or casing 44 free of cement.

The upper end of the casing sections 44, 48 may be provided with sealing and locking arrangements suitable to provide a fluid tight and secure coupling at the overlaps 46, 50.

CLAIMS

1. A method of lining a drilled bore, the method comprising the steps:

(a) running a first tubing length of a first diameter into the bore;

(b) expanding said first tubing length to a larger second diameter;

(c) running a second tubing length into the bore, such that an upper end of the second tubing length overlaps with a lower end of the first tubing length;

(d) expanding the upper end of the second tubing to a third diameter larger than said first diameter but smaller than said second diameter; and

(e) expanding at least a further portion of the remainder of the second tubing length to said second diameter.

2. The method of claim 1, further comprising cementing the first tubing length and allowing the cement to set before expanding the second tubing length.

3. The method of claim 1 or 2, wherein expanding the upper end of the second tubing length to said third

diameter crates at least one of a hanging support and a seal between the upper end of the second tubing length and the lower end of the first tubing length.

4. A method of lining a drilled bore, the method comprising the steps:

(a) running a first tubing length into the bore;

(b) running a second tubing length having a first diameter into the bore, such that an upper end of the second tubing length overlaps with a lower end of the first tubing length;

(c) expanding a lower portion of the second tubing length to a second diameter larger than said first diameter; and

(d) expanding the upper end of the second tubing to a third diameter larger than said first diameter but smaller than said second diameter

5. The method of claim 4, further comprising cementing the first tubing length and allowing the cement to set before expanding the second tubing length.

6. The method of claim 4 or 5, wherein expanding the upper end of the second tubing length to said third diameter creates at least one of a hanging support and a seal between the upper end of the second tubing length and

the lower end of the first tubing length.

7. A method of expanding tubing downhole, the method comprising the steps of:

running tubing of a first diameter into a bore;

expanding a first section of the tubing to a second diameter; and

expanding a second section of the tubing to a third diameter.

8. The method of claim 7, wherein the first and second expansion steps take place simultaneously.

9. The method of claim 8, further comprising:

running first and second expansion tools downhole on a common support, and

operating the expansion tools simultaneously on different sections of the tubing.

10. The method of any of claims 7 to 9, wherein the second expansion step follows the first expansion step.

11. The method of claim 10, further comprising:

expanding the first section of the tubing to the second diameter using an expansion tool; and then

expanding the second section of the tubing to the

third diameter using said tool.

12. The method of claim 10, further comprising:

running a first expansion tool into the bore;

expanding the first section of the tubing to the second diameter using said first expansion tool;

running a second expansion tool into the bore; and

expanding the second section of the tubing to the third diameter using said second expansion tool.

13. The method of any of claims 7 to 12, wherein the third diameter is larger than the second diameter.

14. The method of claim 13, wherein the second section of tubing is expanded to said second diameter before being expanded to said third diameter.

15. The method of any of claims 7 to 14, wherein the tubing is provided as a single tubing length.

16. The method of any of claims 7 to 14, wherein the tubing is formed of a plurality of individual tubing lengths.

17. The method of claim 7, wherein the tubing is formed of a plurality of individual tubing lengths, and the tubing

lengths are run into the bore and expanded separately.

18. The method of claim 17, wherein ends of adjacent tubing lengths are located relative to one another to create an overlap.

19. The method of claim 18, comprising the steps:

(a) running a first tubing length into the bore;

(b) expanding said first tubing length to said second diameter;

(c) running a second tubing length into the bore, such that an upper end of the second tubing overlaps with a lower end of the first tubing length;

(d) expanding the upper end of the second tubing to said third diameter; and

(e) expanding at least a further portion of the remainder of the second tubing length to said second diameter.

20. The method of claim 19, further comprising running in and expanding further tubing lengths to create a lined bore of substantially constant diameter, corresponding to said second diameter.

21. The method of claim 18 or 19, wherein the difference between the second and third diameters corresponds to the

wall thickness of the second tubing.

22. The method of any of the preceding claims, wherein the tubing comprises solid-walled tubing.

23. The method of any of the preceding claims, wherein the tubing comprises slotted tubing.

24. The method of any of the preceding claims, wherein the tubing comprises expandable sand screen.

25. The method of any of the preceding claims, further comprising utilising an expansion tool in the form of an expansion cone and wherein at least part of the expansion is achieved by means of moving the expansion cone through the tubing.

26. The method of any of the preceding claims, further comprising utilising an expansion tool in the form of a roller expander and wherein at least part of the expansion is achieved by means of rolling expansion.

27. The method of any of the preceding claims, further comprising utilising a fixed diameter expansion tool.

28. The method of any of the preceding claims, further

comprising utilising a variable diameter expansion tool.

29. The method of claim 22 when dependent on any of claims 7 to 14, further comprising:

expanding the first section of the tubing to the second diameter using the expansion tool in a first configuration; and

expanding the second section of the tubing to the third diameter using the expansion tool in a second configuration.

30. The method of any of the preceding claims, further comprising expanding at least one section of the tubing to a non-uniform diameter using a compliant expansion tool.

31. The method of any of the preceding claims, further comprising utilising a retractable expander.

32. A method of expanding tubing downhole, the method comprising the steps of:

running tubing into a bore;

expanding a first section of the tubing; and

expanding a second section of the tubing, wherein the expanded first and section sections are of different diameters.

34. A method of expanding tubing downhole, the method comprising the steps of:

running tubing into a bore; and

expanding a portion of the tubing, intermediate the ends of the tubing, to a larger diameter.

35. A lined bore made in accordance with the methods of any of the preceding claims.

EXPANSION METHOD

ABSTRACT

A method of expanding tubing downhole comprises the steps of: providing tubing (14;44) of a first diameter; running the tubing into a bore (10;40); expanding a first section of the tubing to a second diameter, and expanding a second section of the tubing to a third diameter.

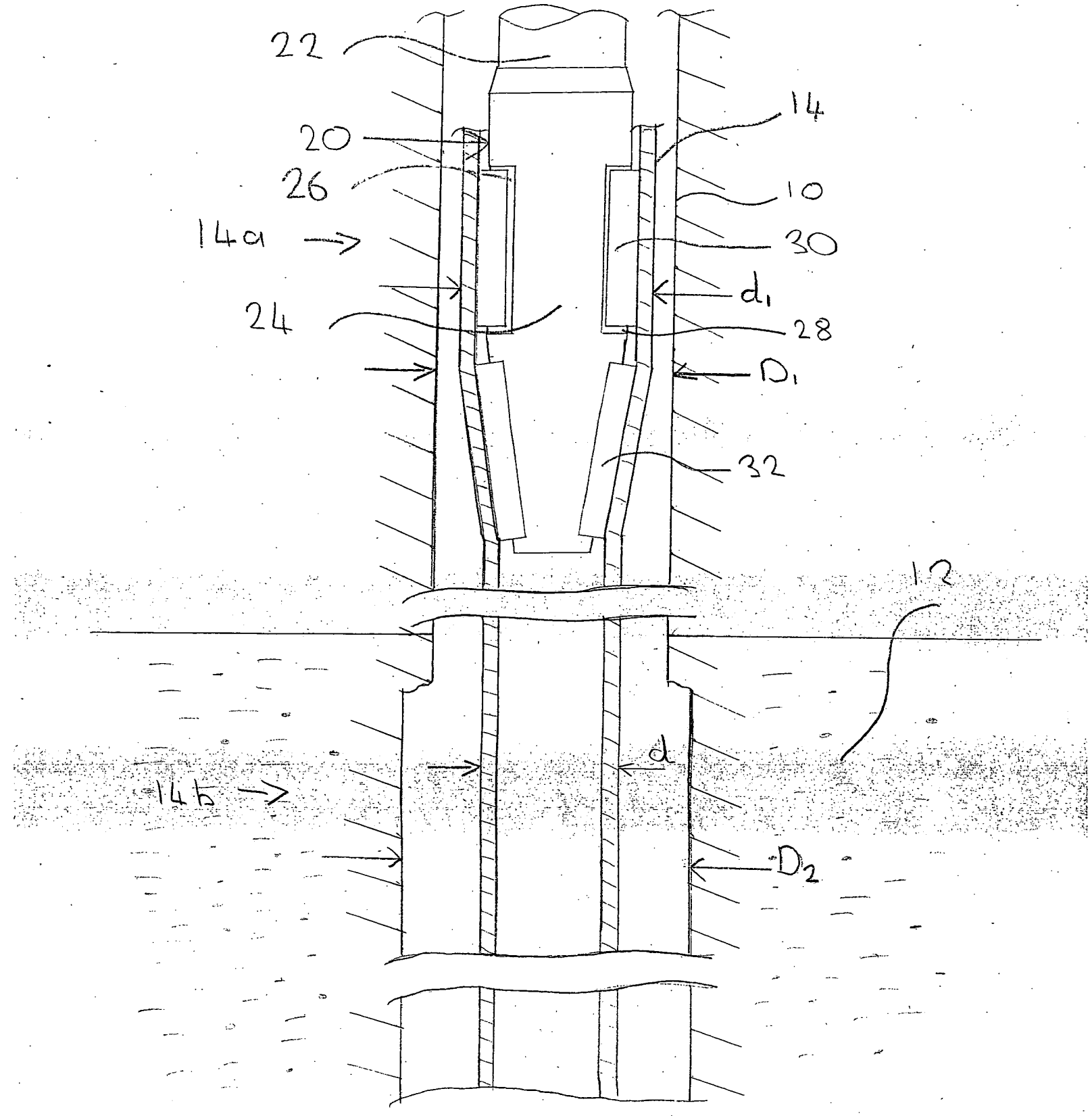

FIG 1

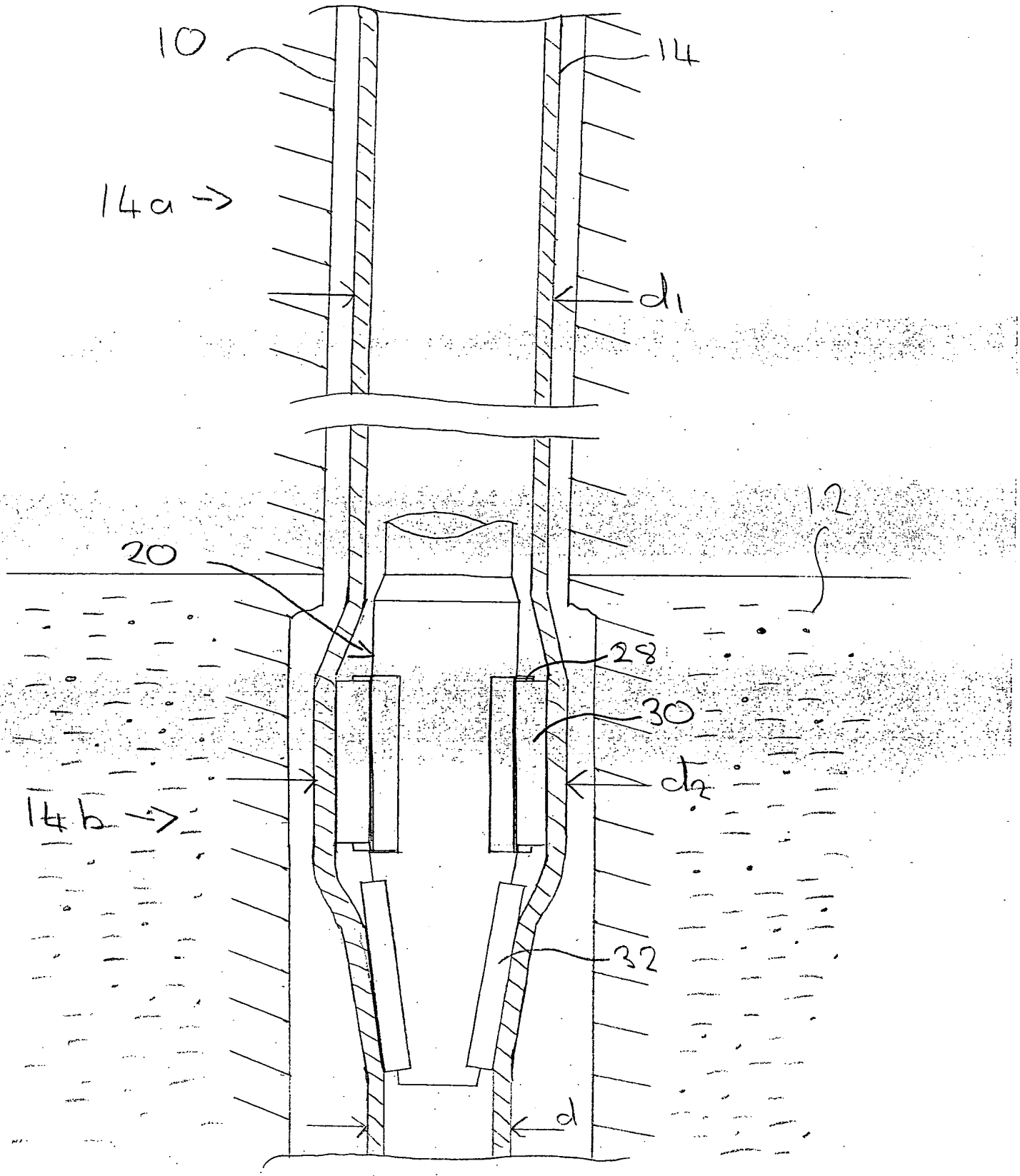

FIG. 2

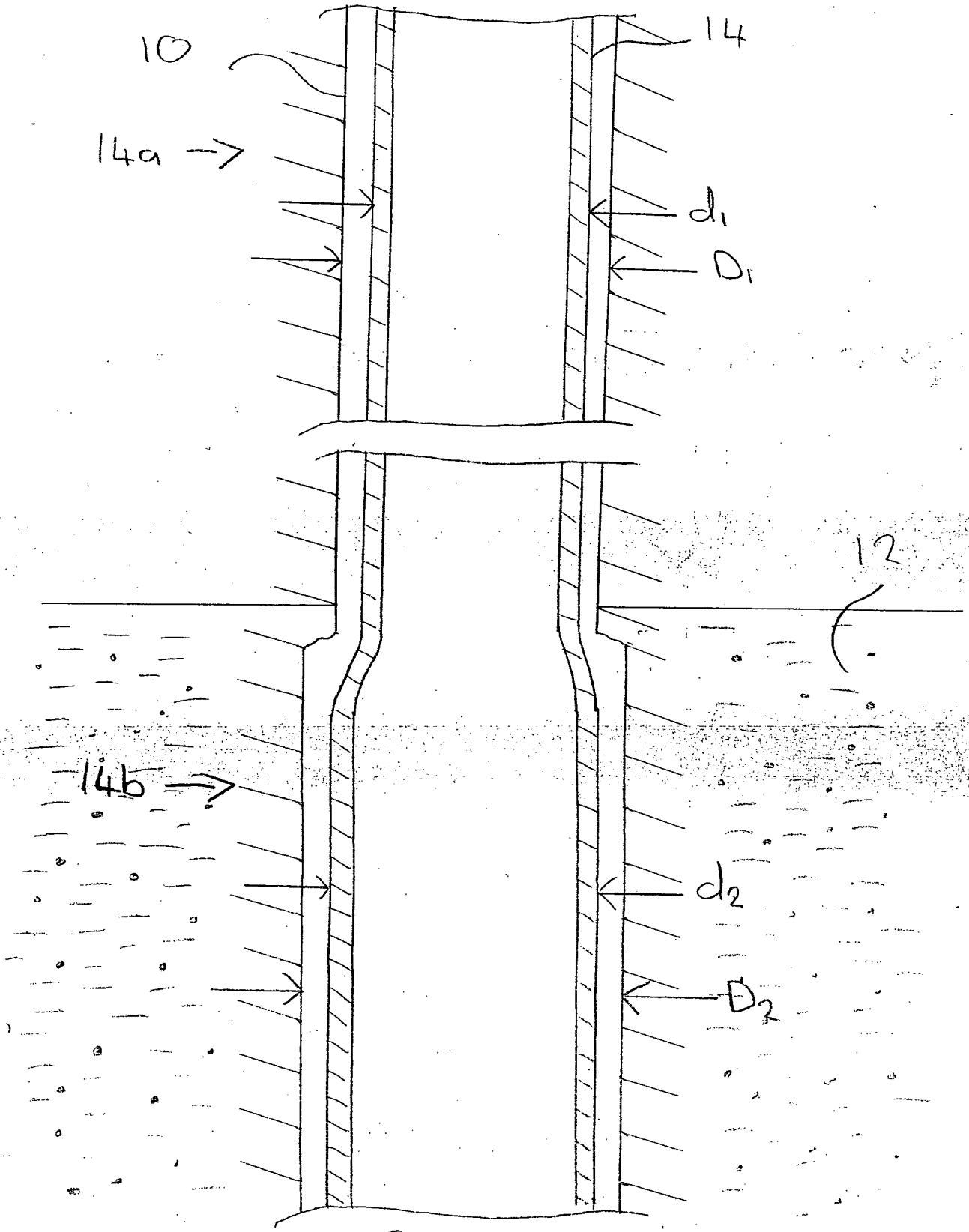

FIG 3

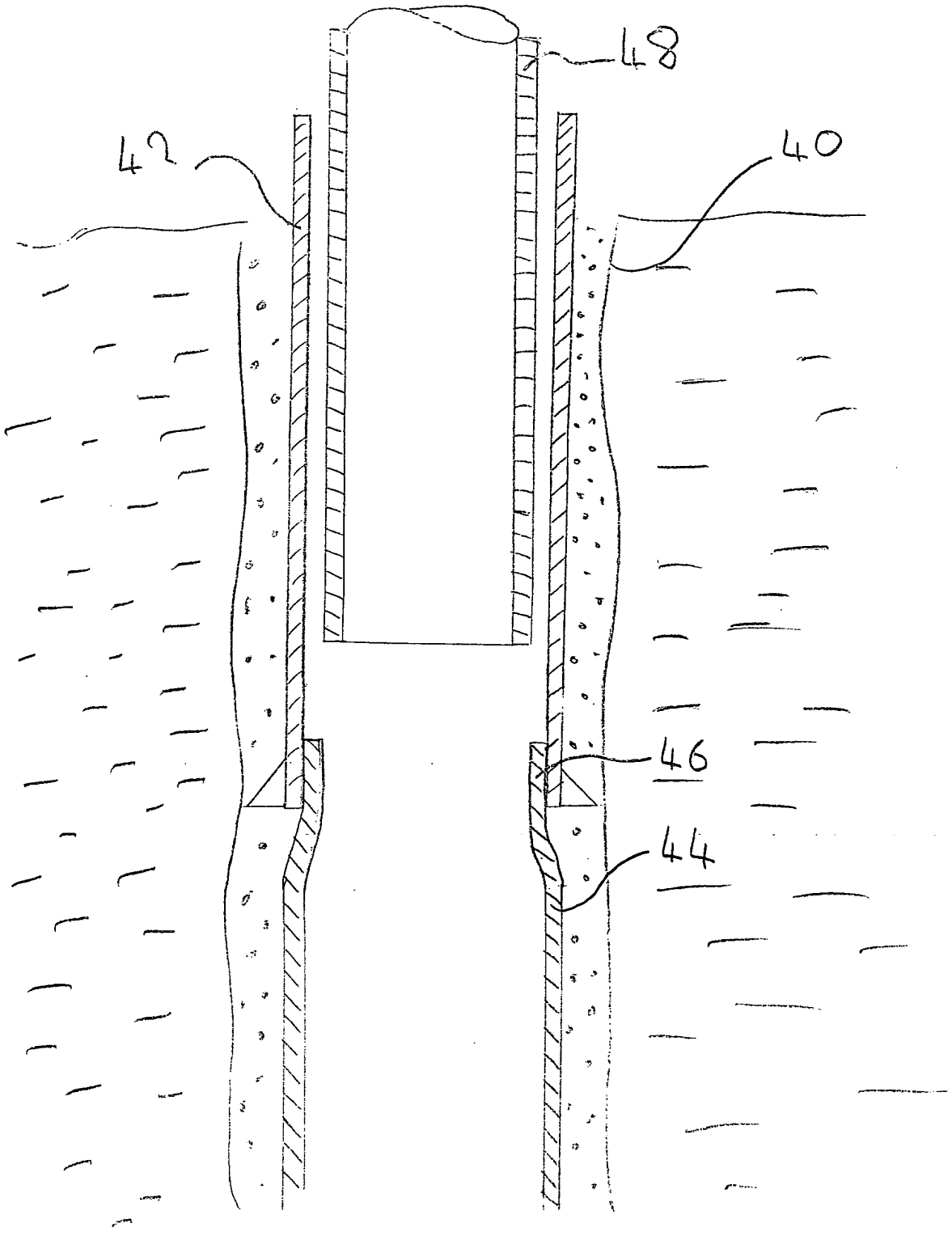

FIGURE 4

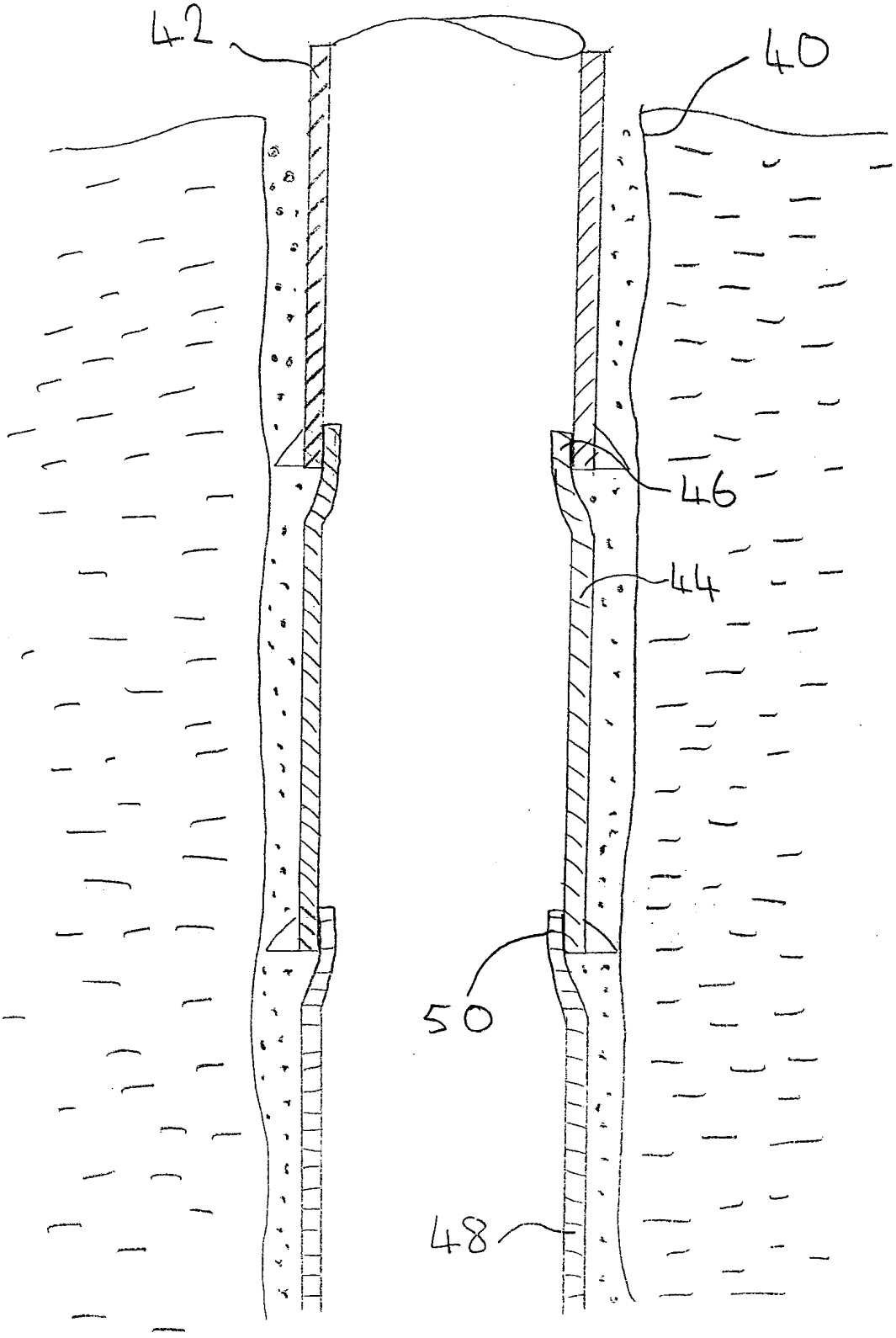

FIGURE 5